BAUXITE WASTE BRICKS (JAMAICA)

EVALUATION REPORT - JUNE 1991

Prepared for

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by

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INTRODUCTION

There is a very pressing need for affordable building materials in Jamaica, particularly for low-cost housing in rural areas. There is also a substantial supply of low grade bauxite waste, "red mud", from the bauxite/aluminum industry at a number of rural locations. In 1987 the International Development Research Centre (IDRC) in Ottawa approved a grant

- to research and develop a low-cost, low-energy brick that meets health and safety standards;
- to develop an appropriate technology for brick production and an appropriate design for local rural construction;
- to construct a prototype building to demonstrate the efficacy of the technology; and
- to disseminate information on these developments to relevant agencies and to the construction industry.

Participating partners in this research and development are the Jamaican Bauxite Institute (JBI), the University of the West Indies (UWI), the Building Research Institute (BRI), and the University of Toronto (UT). Overall responsibility in Jamaica for coordination and implementation lies with JBI, and UT was charged with the responsibility of carrying out joint research in every stage of the project except construction and dissemination of information.

The project has proceeded through the stages of scientific and technical research to brick production, and construction of a demonstration building has started.

Now, four years since project approval, IDRC has commissioned an independant evaluation, this being the subject of the present report. The report is based on:

- a review of the 1987 Project Summary and files at the IDRC office in Ottawa;
- an examination of the first (1987/88) and second (1988/89) annual reports prepared by JBI, and a set of plans for building construction - all supplied by JBI;
- meetings with JBI, UWI and BRI project participants at JBI in Kingston;
- a tour of the project at JBI;
- a tour of facilities at BRI; and
- a tour of the Alcan Jamaica red mud dry-stack facility at Ewarton.

This evaluation report follows the general format outlined in the Terms of Reference of the Consultancy Contract (Appendix B). While all terms are addressed, particular attention is paid to item f) that deals with practical accomplishments. Photographs covering brick production are included in Appendix A.

No participant from UT was consulted in the evaluation.

A. RESEARCH METHODOLOGY

The research methodology followed in this project is appropriate. From the scientific investigation of red mud, through the phase of examining the effects of various admixtures, brick production and curing procedures, to the present planning of prototype building construction, the sequence is logical. The project has both scientific and technical merit in that it has proceeded from a scientific investigation to a reasonable degree of technical accomplishment, although the final objective - safe and durable low-cost housing - has yet to be fully demonstrated.

I am not aware of similar work in the use of bauxite waste for building components. The main novelty of the work is in the production of sun-dried bricks that have been rendered stronger and more durable through the impregnation of sodium silicate. The scientific investigation into the structure of the product and of the bonding mechanisms have contributed to knowledge in this field.

B. CONTRIBUTION TO JAMAICAN RESEARCH CAPABILILTY

All Jamaican institutions (JBI, UWI and BRI) involved in the project have considerable expertise, most of it pre-dating this project, but a significant amount has been acquired through the various stages. This is evident from the reasonable progress made dealing with a relatively difficult material and process.

As further evidence of the quality of the present work I understand that two papers co-authored by UWI and JBI have been accepted for publication in scholarly journals, while two more have been submitted.

C. PARTICIPATING RESEARCH INSTITUTIONS

The participating research institutions, JBI, UWI, BRI and UT are collectively of high quality for undertaking this project, each with its own area of expertise. From progress reports, field observations and discussions, it appears that each is assuming its appropriate share of participation. Local participants, noted below, whom I met, appear to have the education, experience and confidence to undertake this project.

UWI	Dr. Willard Pinnock, Department of Physics
JBI	Mr. Dennis Morrison, Director
	Ms Andrea Frances, Past Project Leader
	Mr. Wesley Harley, Project Leader
BRI	Mr. Dave McLeod, Materials Scientist
	Mr. Junior Gordon, Materials Scientist
Engineer	Dr. Paul Brown, Structural Consultant

D. COLLABORATION

As a follow-up on C. above, it is clear from the relatively smooth progress of this project that partners in the project collaborate effectively. If there was any lack of collaboration it was not apparent during this visit, and must have been handled effectively by the former Project Leader, Ms Andrea Francis, who is leaving JBI to pursue an M.B.A. degree in Canada. Successful completion of the project is reliant upon continued collaboration as more practical phases, such as design, construction and observations of durability, are embarked upon. There is no observable reason to suspect that the collaboration will not continue.

The extent of the contribution and collaboration of UT in the project was not fully appreciated in this evaluation, not because of comments passed in the discussions, but because there did not appear to be any pressing need to discuss the matter at this stage.

E. TRAINING ACTIVITIES

It may be premature to embark upon an extensive program of training and dissemination of information at this stage. However, from field reports plans are being formulated for a two-day information seminar at JBI, Kingston, some time in 1992. It is intended that the seminar be directed towards appropriate government agencies, the media, and architects, engineers and building contractors.

Quite apart from resolution of technical problems is the problem of social acceptability. In Jamaica, concrete is considered to be the accepted building material of permanence, particularly concrete block in house construction. There is also a national concern about the emission of radiation from red mud. The Seminar is important, as a first step, in allaying fears about radioactive emissions, and also in promoting the acceptability of brick construction as a substitute for concrete block. I recommend that the Seminar not be held until the demonstration building at JBI has been completed and is fully functional. A half-finished building will not carry a positive image.

F. ACHIEVEMENTS

The objectives of this project, as taken directly from p5 of the 1987 Project Summary, are as follows:

(i) to study the characteristics and rheological properties of red muds and non-commercial bauxites to establish the relationship between the properties of various red muds and non-commercial bauxite compositions and their production requirements;

(ii) to study the effects of compositional changes of red muds and non-commercial bauxite with other available naturally occuring resources, including natural fibres;

(iii) to study the effects of bonding agents such as lime, fly ash on the properties of the composites prepared in (i) above, with a view of minimizing the energy requirements and production costs;

(iv) to formulate the product specification of bricks from studies mentioned in i), ii) and iii);

(v) to develop a technically and economically viable system (including prototypes) for the production of bricks;

(vi) to assess the properties and determine the capabilities of the bricks so as to meet appropriate health and safety standards; and

(vii) to disseminate the results of the technological developments and to construct a prototype to illustrate the technology.

Objectives i), ii) and iii) are well in hand, a good level of understanding of the various properties of red mud and their interaction with a number of additives having been attained. Since this work is well documented in the annual reports, it is sufficient to summarize that at the present stage of development of this project, impregnation of red mud bricks with sodium solicate, by soaking, produces what appears to be the most appropriate product, vacuum impregnation being too sophisticated for rural use.

As with most research of this nature, a complete understanding is never likely and there is the potential for continued research in order to find an even more suitable receipe for the material.

Objective iv), specifications for brick production, lies sometime in the future. There is still some work to be done on proving the quality of the product. Although BRI is confident their strength and durability tests prove that the product is adequate, I recommend that tests of brick strength be supplemented by compression tests on mortared specimens three to five units high, and that considerably more than 12 wetting and drying cycles be used as a standard for assessing durability. In other words, I feel that strength and durability have yet to be fully verified.

Objective v), namely a viable system for the production of brick, has been attained - subject to some conditions. The process at present depends on two pieces of machinery - a smaller electric grinding machine and a diesel powered machine that produces two bricks at a time, and fairly rapidly. While the machinery is reasonably suitable for rural application, an element of skill on the part of the operator is required - one that requires suitable training. For example, a suitable moisture content of the hand-mixed ingredients is crucial to an adequate brick. However, this may be a skill that is learned fairly rapidly, since incorrect moisture content - either too little or too much - will lead to a brick that cannot be handled without damage.

Objective vi), namely, that of meeting health and safety standards, has in large part been solved - subject to the comments under item iv) dealing with strength and durability testing.

Objective vii), dissemination of information is dealt with under E above.

The project comes to fruition with the construction of a prototype building on the JRI property. The choice of a sports club building is not inappropriate since it serves a useful purpose, and will be in a high-profile location. The project requires additional funding to complete this stage.

Still to be developed are simple plans for a basic building for rural construction, one that is suitable for an earthquake and hurricane zone, but one that can be built by relatively unskilled labour.

G. IMPACT ON DEVELOPMENT

There is no question that there is a need in rural Jamaica for low-cost durable housing, and the present project appears to be well directed towards meeting that need. There is an immense quantity of bauxite waste - the Ewarton Alcan Plant alone has dry-stack beds covering more than 250 acres up to 10 feet deep - that lies begging to be used. I am not familiar with the land ownership/rental/squatter situation, and consequently, of the need for permanent vis-a-vis temporary-squatter housing. However, it appears that the need is there and red mud brick, with more development and promotion, can provide a viable solution.

CONCLUDING COMMENTS

Although brick production and construction have been practised for millennia, it is only with traditional materials that the process is relatively static. Utilization of new materials, production and curing processes inevitably lead to the need for research, especially so if the material is particularly different, as is the case with red mud. With an apparent pressing need in Jamaica for low-cost housing, time constraints require a well planned and coordinated program of research and development. Inevitably, as is the essence of all research, the unexpected is encountered and ways are sought to solve these problems.

At this stage of the red mud brick project it is possible to look back and assess that in its scientific/technical approach to date the project has been well handled and reasonably successful. The fact that the project is somewhat behind schedule is not unexpected.

One of the main objectives of the project, the low-energy production of bricks from red mud has been accomplished, although I recommend further strength and durability tests to fully assess the quality and prove the acceptability of the product. The question of social acceptance of the new material is being addressed in the planned information seminar. However, such a seminar should not be undertaken until the demonstration building has been completed. The project will require financial assistance in completing the building.

The overall objective, low-cost housing, has yet to be realized. If the red mud brick, as now developed, were to be manufactured and sold by a masonry producer, there would be little, if any, cost saving. However, the intent being local rural production, there should be considerable saving over concrete block construction, the main competitor. The process of manufacture, as developed, is relatively uncomplicated although users will require training. The machinery used is appropriate, but its availability was not assessed in this evaluation.

An architectural/structural engineering design that meets code requirements for earthquake and wind but yet is simple enough for rural construction has still to be developed.

In summary, many of the research and development objectives have been accomplished. There is still work to be done but, although understandably behind schedule, the project appears to be on track for coming to fruition.

ACKNOWLEDGEMENTS

The assistance provided by staff at JBI and BRI is gratefully acknowledged.

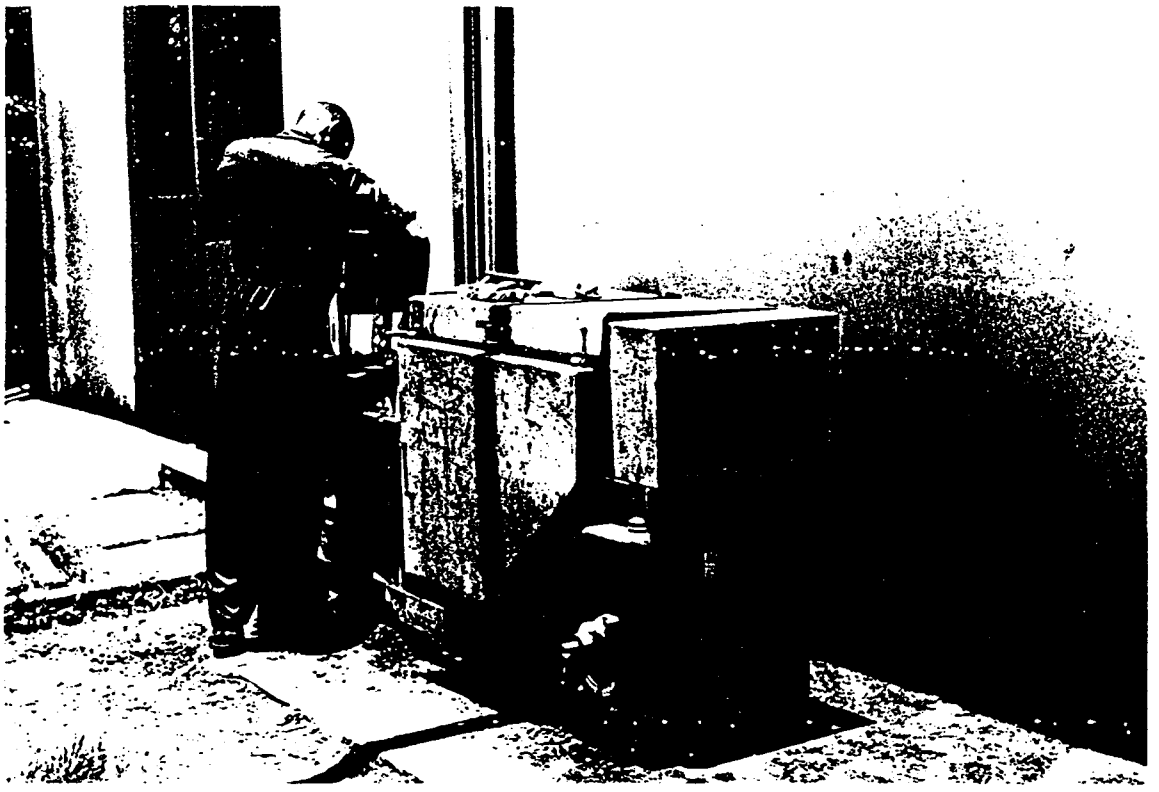
Do not scan images (appendix)

APPENDIX A

PHOTOGRAPHS

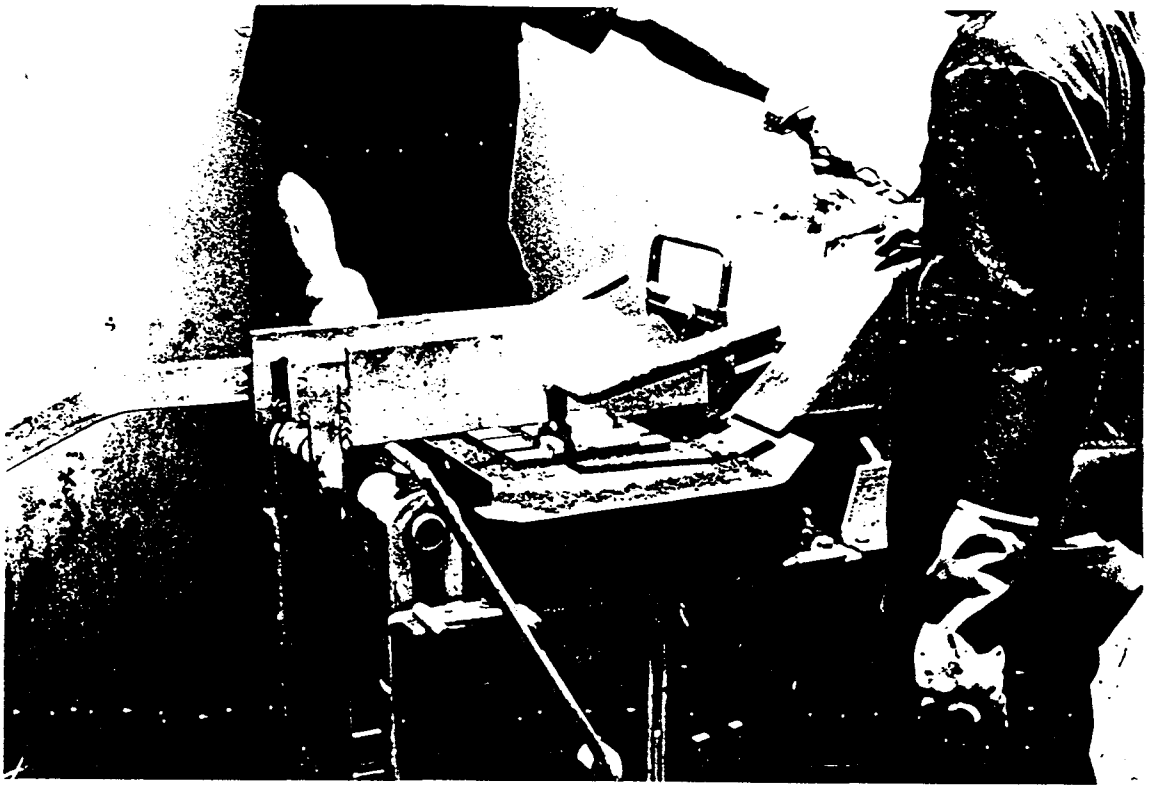
ADDING WATER TO GROUND RED MUD

HAND MIXING

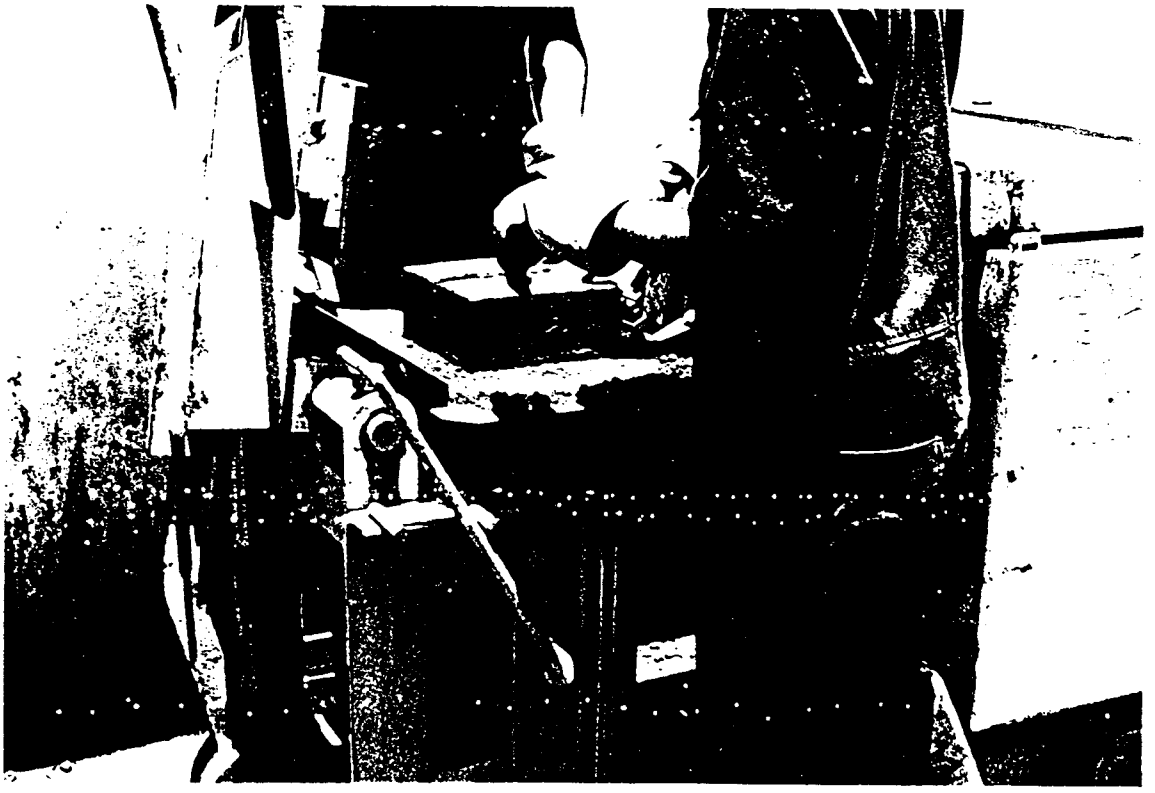


DIESEL POWERED TWO-BRICK MACHINE

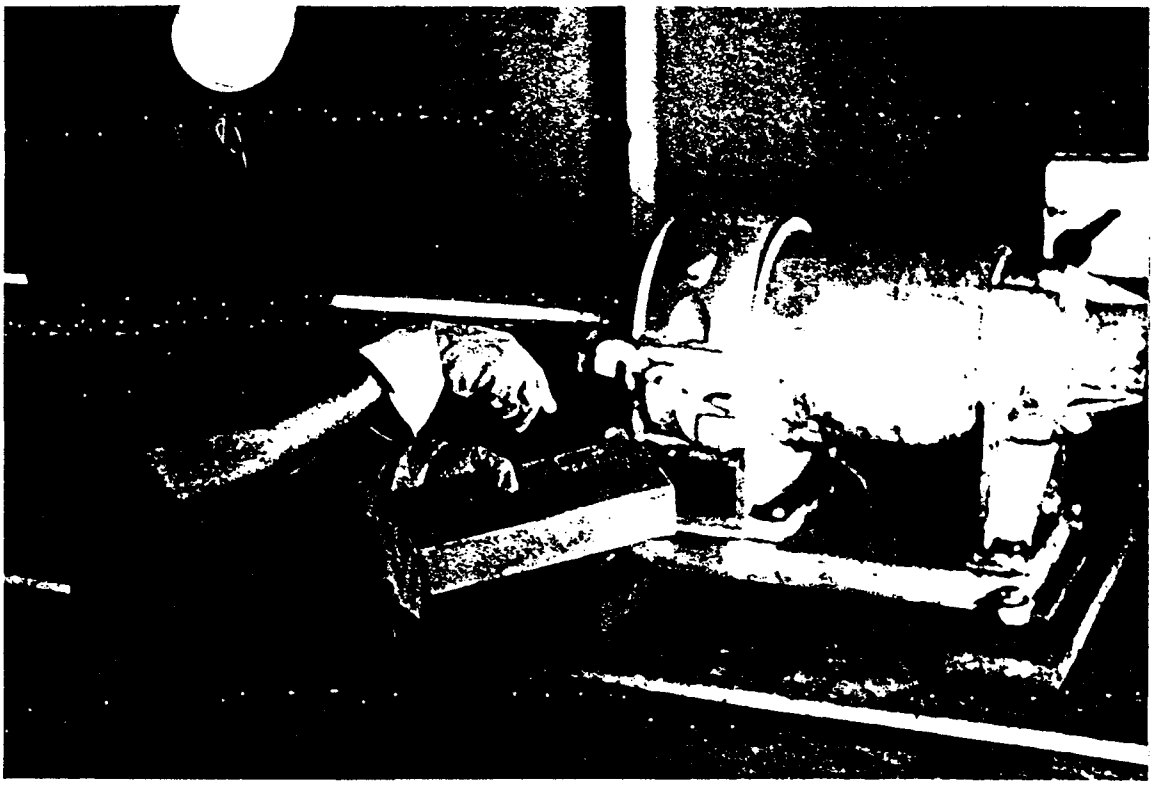
ADDING MIX TO BRICK MOULD



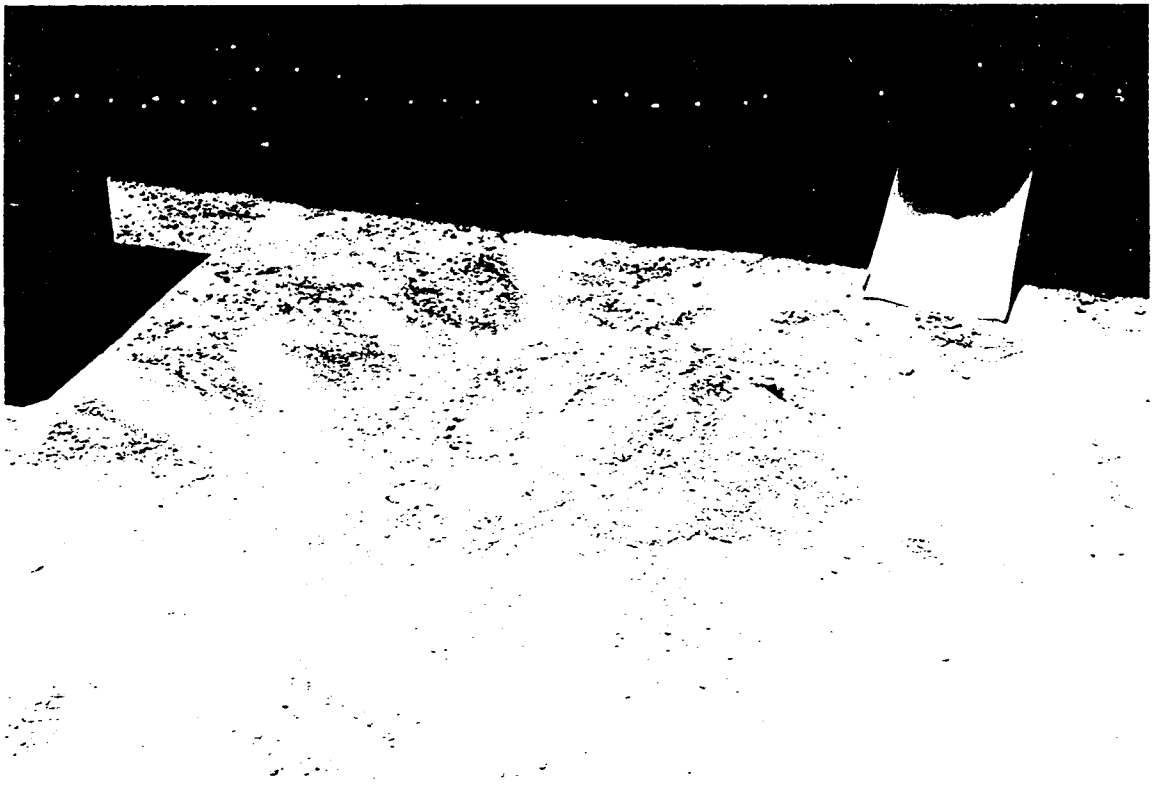
BRICKS BEING COMPRESSED



BRICKS AS PRODUCED BY MACHINE



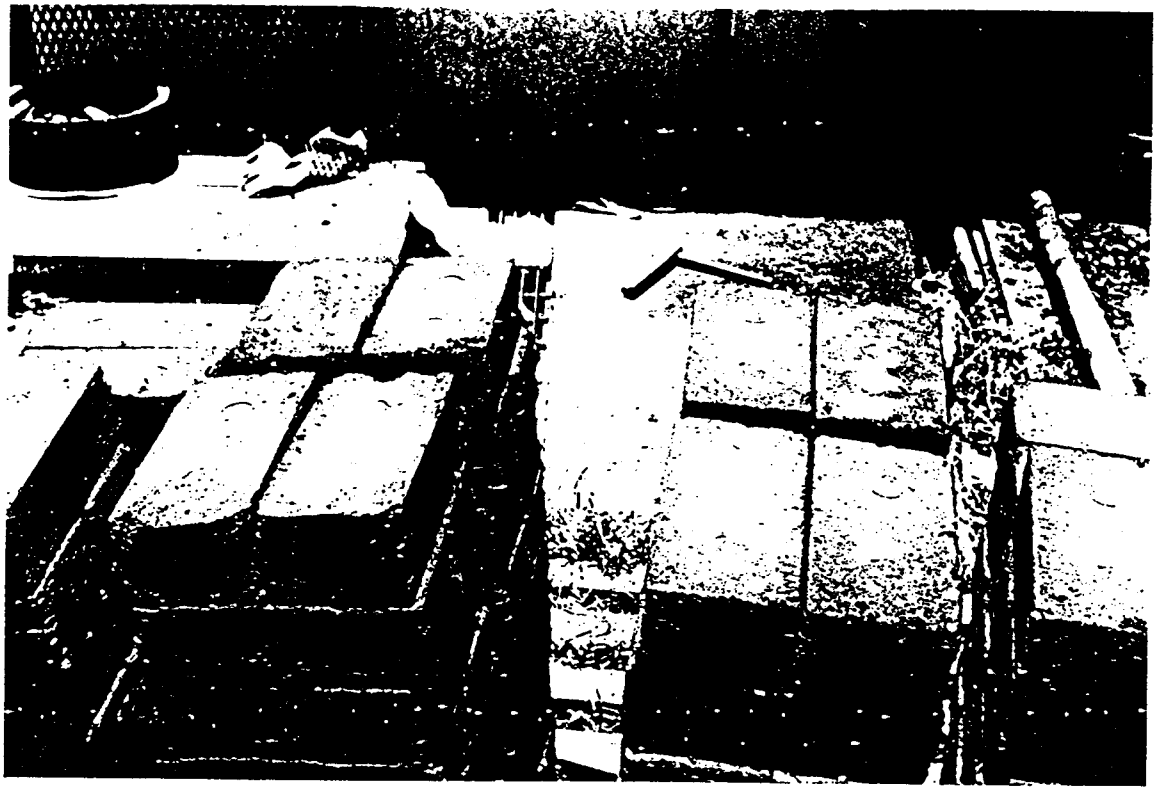
PORTABLE GRINDING MACHINE



GROUND RED MUD READY FOR MIXING

"RED MUD" DRY-STACK FACILITY AT ALCAN PLANT, EWARTON

After removal of alumina the sodium hydroxide / bauxite waste is pumped from the plant (background) to "dry-stack" beds for draining, sodium hydroxide recovery and drying prior to next pour. The facility has about 250 acres of dry-stack beds up to 10 feet thick.

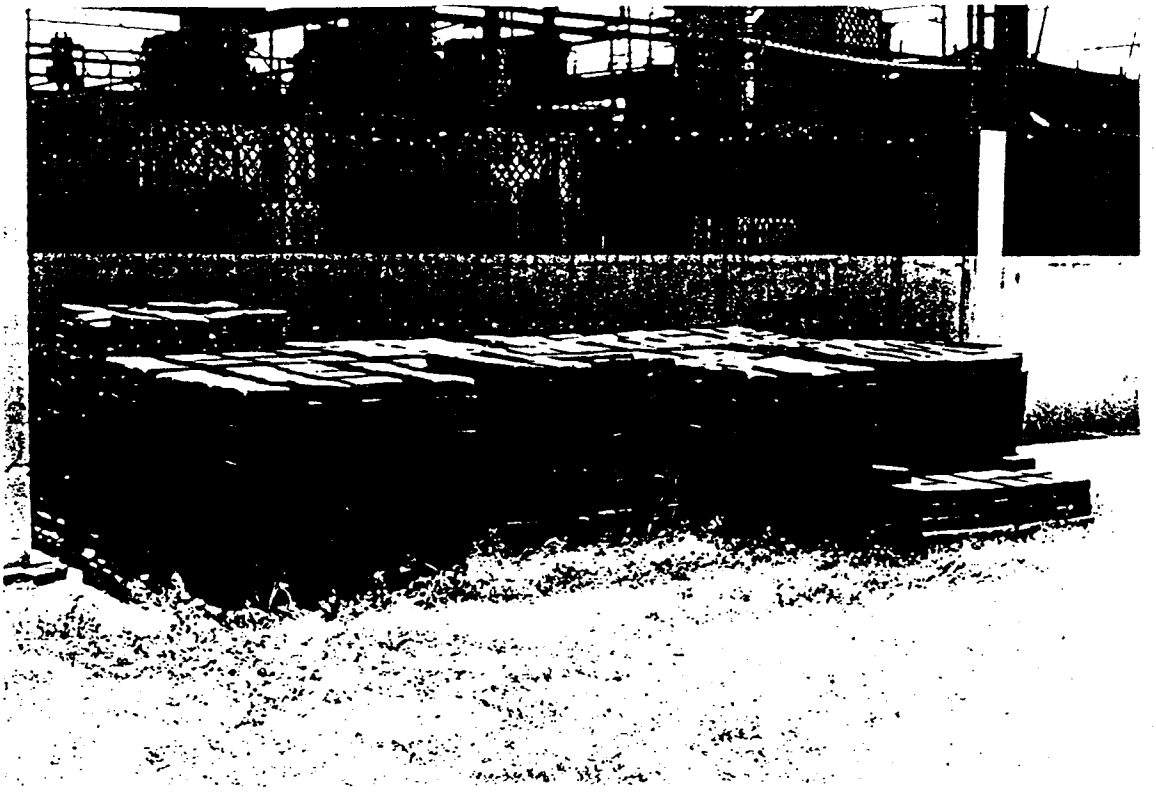


BRICKS FROM MACHINE

SUN DRYING PRIOR TO IMMERSION IN SODIUM SILICATE SOLUTION

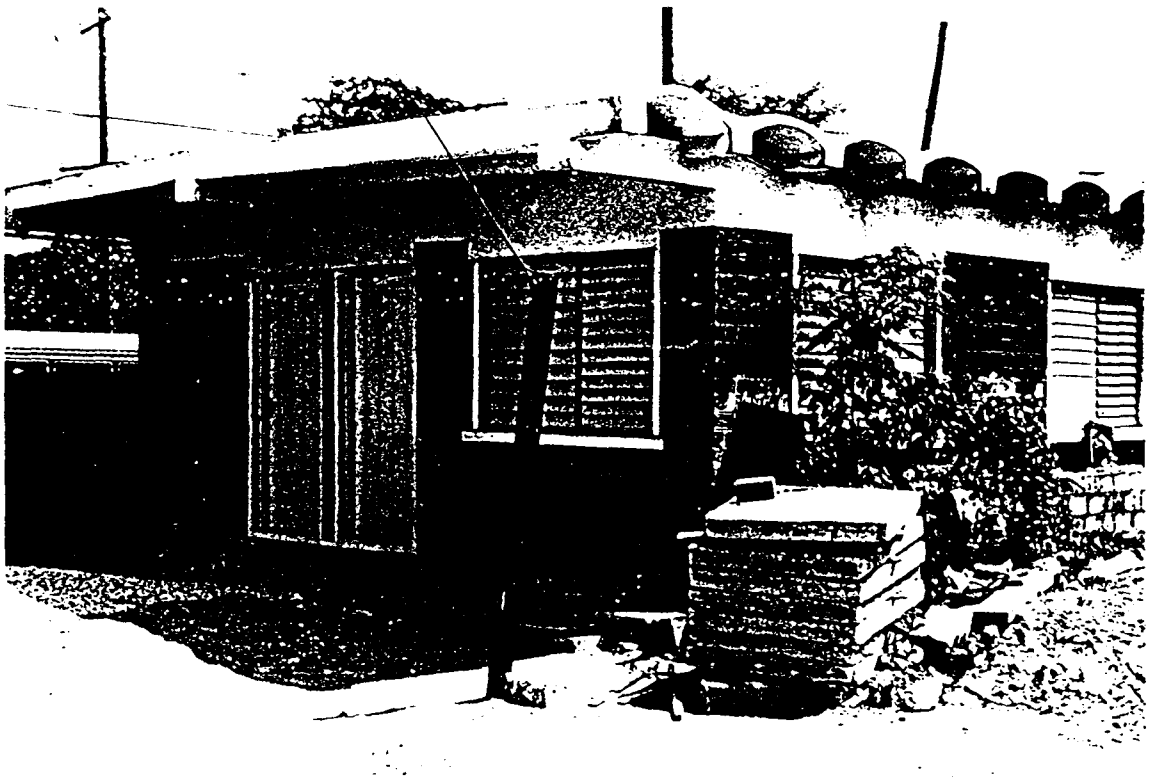
SODIUM SILICATE SUPPLY

SOAKING TRAYS



FINAL PRODUCT STOCKPILED AND SUN-DRYING

PREPARING FOR BRICK CONSTRUCTION
Vertical reinforcing is for cavity wall construction



EARLIER CEMENT STABILIZED BRICK IN TRIAL BUILDING AT BRI